

Chapter 3: Fossil Fuels—Coal Gasification—Integrated Gasification Combined Cycle (IGCC) Coal Power Plants

For additional charts and graphs related to coal-based electricity, please refer to the *Kansas Energy Chart Book*, Chapter 3 (http://kec.kansas.gov/chart_book/).

GOAL: Increase opportunities to generate electricity through integrated gasification combined cycle (IGCC) coal power plants, in association with carbon dioxide capture and storage capabilities.

Developing low-emission energy-generation technologies is an essential component of a comprehensive, long-range strategy to meet the state's future energy needs.

Topic/Issue Description

Coal is the world's most abundant and widely distributed fossil fuel resource. Some 23% of the world's primary energy needs are met by coal and 39% of the world's electricity is generated from coal. About 70% of world steel production depends on coal feedstock.

The U.S. has the world's largest coal reserves, which analysts believe are sufficient for the next 200 to 250 years.¹ In Kansas, coal is used to generate 74% of the electricity consumed, compared to 52% nationally. For the foreseeable future, coal is forecasted to remain one of the lowest-cost electric power sources in Kansas and the rest of the country.

However, coal-fired power plants are responsible for 60% of U.S. sulfur dioxide emissions, 33% of U.S. mercury emissions, and 25% of U.S. nitrogen oxide emissions. In addition to these pollutants, U.S. coal-fired power plants are also responsible for more than 33% of the nation's greenhouse gas (carbon dioxide) emissions. Worldwide, burning coal produces about 9 billion metric tons of carbon dioxide each year that is released to the atmosphere, about 70% of this being from power generation. Other estimates put carbon dioxide emissions from power generation at one quarter to one third of the world total of over 27 billion metric tons of CO₂ emissions.

The use of coal for electrical generation is growing worldwide. U.S. utility companies have announced their intention of building more than 100 new coal plants over the next 10 to 15 years. Currently, China is building the equivalent of one large coal-fired plant each week.

¹ Steve Quinn, October 15, 2006, "U.S. coal plant boom poses big environmental, economic questions" (Associated Press story).

Given the expected 60-year life span of these plants, this new coal-fired generation could collectively release an enormous amount of carbon dioxide as well as other pollutants into the atmosphere. Development of integrated gasification combined cycle (IGCC) coal power plants in association with carbon dioxide capture and storage—not just in Kansas, but worldwide—is a vital component of any strategy to reduce emissions of greenhouse gases and other pollutants into the atmosphere.

In IGCC systems, coal is not combusted directly (as it is in conventional coal-fired plants). Instead, the coal reacts with oxygen and steam to form a so-called syngas (primarily hydrogen) and solid slag (containing much of the traditional pollutants). After additional cleaning, the syngas is burned in a gas turbine to generate electricity and to produce steam to power a steam turbine.

IGCC plants have been tested as a means of using coal and steam to produce hydrogen and carbon monoxide, which are then burned in a gas turbine with secondary steam turbine (i.e., combined cycle) to produce electricity. If the gasifier is fed with oxygen rather than air, the flue gas contains highly concentrated CO₂ that can readily be captured, at about half the cost of capture from conventional plants. Ten oxygen-fired gasifiers are operational in the U.S., including one in Coffeyville, Kansas.²

Captured carbon dioxide (CO₂) gas is being used, on a commercial basis, for enhanced oil recovery in West Texas, where today over 1,800 miles of pipelines connect oilfields to a number of carbon dioxide sources in the region. In North Dakota, at the Great Plains Synfuels Plant, roughly 5,000 metric tons per day of CO₂ is piped 320 kilometers into Canada for enhanced oil recovery. Overall in the U.S., 32 million metric tons of CO₂ is used annually for enhanced oil recovery, about 10% of this from anthropogenic sources.

Another way to sequester CO₂ involves injection into deep, unmineable coal seams where it is adsorbed to displace methane (natural gas). This is another potential value-added use or disposal strategy. Currently, the economics of enhanced coal bed methane extraction are not as favorable as enhanced oil recovery, but the potential is considered to be large.

The scale of envisaged future CO₂ disposal far exceeds current use; however, current practices demonstrate the practicality and safety of sequestration on a

² Coffeyville Resources in Coffeyville, Kansas, uses partial oxidation gasification technology to produce approximately 413,200 short tons of ammonia, two-thirds of which is further upgraded to 663,300 short tons of Urea Ammonium Nitrate Solution (UAN) per year. The Coffeyville gasifier converts low-priced petroleum coke into a hydrogen rich synthesis gas (similar to high-BTU coal). The syngas is then converted into anhydrous ammonia; the ammonia is further upgraded into UAN in a fully integrated plant licensed from Weatherly.

small scale. Research on geologic sequestration, particularly in deep saline aquifers and depleted oil and gas fields, is ongoing. In both, the CO₂ is expected to remain as a supercritical gas for thousands of years, with some trapping by dissolution and mineral precipitation. Large-scale storage of CO₂ from power generation will require an extensive pipeline network similar in scale to the existing natural gas pipeline network.

The advantages of IGCC coal power plants that have carbon capture and storage capabilities justify the policy to support this form of generation, once the feasibility of the technologies has been demonstrated (see discussion of FutureGen below).

Existing Policies and Programs

1. FutureGen is a project of the U.S. Department of Energy to build a “near zero-emissions” coal-fired power plant that intends to produce hydrogen and electricity while using carbon capture and storage. FutureGen will be a 275-megawatt power plant expected to take ten years to build and whose cost will be shared: \$620 million by the Department of Energy and \$250 million by a large industrial consortium. It will be operated as a research facility. When operational, the prototype will be the cleanest fossil fuel fired power plant in the world and will establish the technical and economic feasibility of producing electricity and hydrogen from coal, while capturing and sequestering the carbon dioxide generated in the process at an operating rate of one million metric tons per year. The DOE originally predicted it would demonstrate the IGCC and carbon capture and storage technology and have commercial designs available by 2012, but it is likely this was an overly optimistic prediction.
2. The Kyoto Protocol is an agreement made under the United Nations Framework Convention on Climate Change. Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases. As of August, 2006, 165 countries and other governmental entities have ratified the agreement. The United States and Australia, though signatories, have not ratified the agreement.
3. Kansas House Substitute for Senate Bill 303 (passed in the 2006 Legislative session) provides (1) Kansas tax credits for expansion of existing IGCC plants; (2) property tax exemption for any new or expanded IGCC plant; and (3) KDFA revenue bonds for financing of new or expanded IGCC plants.

Policy and Program Recommendations Requiring Legislative Action

1. The Governor and the Legislature shall determine if and how State- and consumer-funded support should be structure to stimulate IGCC coal power plants, in association with carbon dioxide capture and storage.

a. Description

The Legislature is encouraged to investigate the need for additional incentives (e.g., State tax credits, KDFA financing) to stimulate the development of IGCC coal power plants, in association with carbon dioxide capture and storage, and, if deemed necessary, to approve such incentives.

b. Recommended Actions**i. Responsible parties**

Governor, Legislature.

ii. Legislative action

Enabling legislation may be necessary.

iii. Budget Requirements

Some State funding may be necessary, depending on incentives enacted.

iv. Implementation Timeline

Immediately following effective date of enabling legislation.

c. Implications of the proposal***Pros***

- i. Reduces emissions of regulated pollutants.
- ii. Reduces emissions of carbon dioxide.

Cons

- i. Tax credits decrease State revenues and, thus, reduce funding for other items in the State general budget.
- ii. May increase price of electricity for ratepayers whose utility is awarded additional basis points. (Note: unlike tax incentives or KDFA financing, granting an automatic higher rate of return on

utility investment in IGCC coal power plants would increase ratepayer bills.)

- iii. If market conditions change (e.g., the Federal government enacts CO₂ regulation), additional State subsidies may become excessive.

Policy and Program Recommendations Requiring Administrative Action

1. The Governor and the Legislature shall determine if and how State- and consumer-funded support should be structure to stimulate IGCC coal power plants, in association with carbon dioxide capture and storage.

[See above discussion under Recommendations Requiring Administrative Action.]

Policy and Program Recommendations Requiring Action by the Kansas Corporation Commission

1. The Kansas Corporation Commission should consider the advantages associated with of IGCC coal power plants, combined with carbon capture and sequestration, when evaluating applications or requests to approve decisions by jurisdictional utilities to invest in new generation or enter purchase power agreements for IGCC coal power plants. As part of this broader consideration, the KCC will require utilities to demonstrate that competitive bids were solicited and the most responsible selection was made for the purchased power or investment.

Note: This proposal positions the State to take advantage of IGCC and carbon capture and storage technologies, if the FutureGen prototype demonstrates their feasibility.

a. Description

This legislation would enable the KCC to consider the value of lower-emissions coal generation and carbon capture and storage when evaluating investments in or purchase power agreements (PPAs) from jurisdictional utilities for integrated gasification combined cycle (IGCC) coal power plants, in association with carbon dioxide capture and storage capabilities.

It is recognized that, without this consideration, PPAs for IGCC coal power plants may not be cost competitive relative to existing pulverized coal-fired generation.

With this policy, the State recognizes the potential benefit to Kansans of reduced pollutants and greenhouse gas emissions attributable to integrated gasification combined cycle (IGCC) coal power plants, in association with carbon dioxide capture and storage capabilities, and declares that it is appropriate for the Kansas Corporation Commission to approve rates for electricity generated by these technologies, even if those rates are higher than what they would have been with full reliance on conventional coal-fired generation.

b. Recommended Actions

i. Responsible parties

Kansas Corporation Commission; electric utilities (this policy provides for the future adoption of these technologies by Kansas electric utilities).

ii. Legislative action

No legislation is necessary.

iii. Budget Requirements

No state funds required.

iv. Implementation Timeline

Effective January 2007, the KCC is encouraged to implement this broader consideration.

c. Implications of the proposal***Pros***

- i. Reduced emissions of regulated pollutants.
- ii. Reduced emissions of carbon dioxide
- iii. Increased ability to use higher-sulfur Kansas coal in IGCC systems.
- iv. Suitability of the state's geologic formations (e.g., depleted oil and gas reservoirs) for carbon sequestration.
- v. Does not require additional state funding or result in additional loss of tax revenues.

Cons

- i. Increases price of electricity to ratepayers whose utilities invest in IGCC power plants with carbon capture and storage.
- ii. May disadvantage the state economically in the absence of federal carbon regulation.
- iii. Uncertainties associated with feasibility of carbon capture and storage.

Policy and Program Recommendations for Ongoing Study

(None)